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THE EQUILIBRIUM FUNCTIONS OF THE INTERNAL EAR[1]

IN this paper I have not attempted to survey the whole range of present-day problems on the functions of the labyrinth but have confined myself to some phases of two fundamental questions. (1) What and how much differentiation of function can be proved to exist in the different labryinthine structures concerned in equilibrium? (2) How does movement or change of position of the body give rise to the excitation process in the labyrinth?

I wish to state at the outset that merely for the sake of brevity specific mention will not be made of the reasons for assigning the functions discussed to the inner ear rather than to the movement of retinal images or to other sources of sensory stimuli, but must have it understood that those possible errors have not been left uncontrolled. Furthermore I have dealt with the phenomena objectively, because the experimental work which can throw light on these questions has necessarily been done upon animals in which the postulation of subjective sensations is unsafe or unnecessary. Furthermore I have not been unmindful of the fact that the reactions in the form of compensatory movements and forced positions include the simultaneous activity of many muscle groups, but I have used the compensatory movements of the eyes as the most convenient index of the labyrinthine reflexes, and also as the simplest to describe.

The labyrinth of the higher vertebrates must be used in the solution of many yet unsolved problems, but for the two fundamental questions now before us it presents insuperable difficulties. On the other hand the ears

[1] Read before a joint session of the American Society of Naturalists and American Society of Zoologists, December 30, 1920.

of Selachians are extremely favorable objects for experiment because of the relatively large size of their parts, their anatomical arrangements which permit the stimulation or extirpation of single portions, the ease and clearness with which operations can be performed through the cartilaginous skull, and the machine-like definiteness with which compensatory movements occur in these animals.

The compensatory movements of the eyes and fins of the dogfish were first accurately described by Loeb (1891). Lee (1893) made a very detailed study of these movements in response to rotation about the different body axes, and laid emphasis on the precision with which similar movements resulted from stimulation of the ampullæ of the different canals.

I. THE SEMICIRCULAR CANALS

(*a*) *Stimulation Experiments*

Lee's description of the results of stimulation of the individual ampullæ is very specific and I (1910) could confirm it in every particular. In brief the results may be thus stated: Stimulation of the ampulla of the right horizontal canal causes both eyes to turn to the left, the same movements as that which occurs when the animal is rotated to the right about its dorsoventral axis. Stimulation of the ampulla of the right anterior vertical canal causes the right eye to be elevated, the left eye to be depressed, and both eyes to roll backward on their axis; these movements are similar to those which occur when the animal is rotated head downward and to the right, that is, in the plane of the canal stimulated. When the ampulla of the posterior vertical canal is stimulated the right eye is elevated, the left eye is depressed and both eyes roll forward on their axes. These movements are identical with those which result from tilting the head upward and to the right, that is, a rotation in the plane of the posterior vertical canal. Of course, the stimulation of the symmetrically placed canals of the other side would merely transpose the use of the words left and right in this description. Ampullæ are exceedingly sensitive to mechanical stimulation. The results are absolutely clear and definite.

(*b*) *Extirpation*

On the basis of the above experiments Lee believed to have proof of the correctness of the Mach-Breuer assumption that the semicircular canals constitute the organ for the dynamic functions of the labyrinth. He attempted to put them out of function by cutting the ampullar nerves, or in some instances by destroying the ampullæ. He states that after cutting the nerves of all four vertical canals compensatory movements are wanting to all rotations in vertical planes, although compensation may be retained to rotation in a horizontal plane. Lyon (1899) on the other hand reported compensatory motions in response to all three rotations, after removal of all six ampullæ. I have developed a very simple and certain method of removal of the ampullæ, and I have repeated these experiments many times (1910, 1919) with the most complete regularity of results. I found that contrary to Lee's statement after removal of the ampullæ of the four vertical canals, or indeed of all six ampullæ, good compensatory movements occur to rotations around the longitudinal or transverse axis, but I have never yet seen the compensatory movements to rotation in the horizontal plane retained after removal of the ampullæ of the horizontal canals. Anyone who will take the trouble to repeat these experiments using my method will be able to see for himself that after loss of all the semicircular canals the labyrinth retains all its static functions, and all its dynamic functions except the response to rotation in a horizontal plane. The dynamic functions then are not confined to the semicircular canals.

II. THE OTOLITH ORGANS

(*a*) *Extirpation*

Experiments by removal of the otoliths have been carried on by many observers. Loeb (1891) found that scratching out the otoliths completely from the vestibule had much the same effect as section of the eighth

nerve. Lee (1893) reported that when the otoliths were removed from both ears compensatory movements were perhaps weakened but were not completely done away with; but that on the other hand the compensatory position was not retained after the movement ceased. Parker (1909) and I (1910) both found that the removal of the large otolith of the sacculus had no effect whatever on the equilibrium reactions, static or dynamic. Moreover I found that after removal of the otoliths from the sacculus and in addition all the six ampullæ good compensatory motions occurred to rotations in all planes except the horizontal if only the little otolith of the recessus utriculi remained uninjured. If now I removed the otolith of the recessus also every trace of labyrinthine reaction permanently disappeared. It made no difference in the result, however, if I omitted the removal of the saccular otolith.

The removal of the otolith from the recessus of the utricle without too great damage to the connection of the utriculus with the mouths of the anterior vertical and horizontal canals, especially the latter, was so great that at first it seemed impossible. In my earlier experiments I was puzzled by the fact after complete removal of the otolith the ampulla of the horizontal canal always ceased to function. When at last I was able to make a small incision through the delicate wall of the utriculus and wash out the otolith with a fine pipette I found not only that compensatory movements occurred in response to rotations in all planes, but that the compensatory positions were retained. Thus it becomes apparent that not only the otolith-organs without the ampullæ but also the ampullæ without the otolith-organs possess both dynamic and static functions. I may say here that in either case, after loss of the ampullæ or after loss of the otoliths, the reactions are noticeably slower and weaker than in the normal animal; evidently the two sets of structures reinforce each other.

(*b*) *Stimulation Experiments*

Stimulation experiments on the otolith-organs have been attempted by many observers but usually with inconstant, contradictory or negative results. Kubo (1906), however, reported very definite responses to stimulation by the application of pressure to the otolith. According to his statements the otoliths have definitely localized functions corresponding to those of the semicircular canals. These localizations corresponded to the statement of Breuer that the otoliths like the semicircular canals are arranged in three planes in space, each responding to motion in its own plane. Kubo states that the otolith of the utriculus when pushed anteriorly causes the eyes to roll backward, that is, to rotate on their axis, nasal pole up, which is the compensatory movement occurring when the head is tilted downward. Moving this otolith backward had no effect. In an analogous manner moving the large otolith of the sacculus backward gave the same movement as tilting the head up, and pushing the same otolith outwards from the median line gave the same reaction as that which comes from rotating the body to the same side around the longitudinal axis. In the light of our present knowledge Kubo's results are perfectly easy to understand, but are of absolutely no scientific value. His experiments were made without removing the ampullæ and he specifically states that they succeeded best when performed without removing "the membranous capsule of the gelatinous mass." In each case the result was just what would occur when he accidentally produced a change of tension on the nearest ampulla.

In order to study the effect of stimulation of any of the labyrinthine structures it is, of course, necessary to make sure that the structure in question is really the one in which the excitation takes place, since, as we have seen, all the compensatory movements which can be excited through the otolith organs in the absence of the semicircular canals can also be excited through the semicircular canals in the absence of the otolith organs. It is then evidently useless to attempt to determine the action of the otolith by stimulation experiments so long as the ampullæ of the canals are in place. The only completely

convincing demonstration of the otolith function is that which can be obtained in the absence of all other parts which could give the same reaction. This I have been able to accomplish in the most definite way (1920*b*).

My experiments on the otolith have been made on several species of sharks and rays. The most favorable animal for this purpose is the shovel-nosed ray or guitarfish, *Rhinobatus productus*. I removed all three semicircular canals with their ampullæ and then washed out the large, soft, friable otolith of the sacculus. There now remained only the small otolith of the recessus. This otolith is shaped somewhat like a plano-convex or concavo-convex lens and rests in a concave depression in which it fits much like one saucer standing in another. The concavity is lined with the characteristic macular epithelium with its hair cells. I found that if I pressed on the anterior side of this otolith the eyes rolled forward on their axes, *anterior pole* downward, that is, they made the same movement which occurs when the head is *tilted upward*. If I pressed on the hinder margin of the otolith the eyes rolled *backward* on their axes, the movement which occurs when the head is tilted downward. Pressure applied to the right margin of the otolith caused the *right eye to be depressed* and the left eye to be elevated, the same movement which results from rotating the animal to the *left* around its longitudinal axis, and this resulted whether the stimulus was applied to the otolith of the right or left ear. The method of stimulation just described very soon injured the delicate otolith and the movements could only be obtained a few times. When, however, I placed a small pellet of wet absorbent cotton on the otolith I could with fine forceps pull the pellet backward or forward or from side to side repeatedly without apparent injury to the otolith. When the cotton was pulled to the right the right eye went down, when pulled to the left the left eye went down, when pulled forward the eyes rolled forward on their axis, when pulled backward both eyes rolled backward.

The above experiment shows that the *a priori* assignment of different functions to different otoliths with reference to the planes in which they lie and the rotational movements of the body to which they correspond does not accord with the facts. All the compensatory movements and positions arising from vestibular stimulation are obtained from this otolith alone. Parker's and my previous observation that the large otolith of the sacculus is not concerned in equilibrium is confirmed. It is of interest, too, to note that the otolith of each ear gives rise to complementary movements in both directions; elevation of the right and depression of the left eye, or depression of the right eye and elevation of the left eye can be obtained from the otolith of either ear.

III. The Mechanism of the Physiological Action of the Otolith Organs

It has been almost universally believed since the publication of the earlier papers of Mach and Breuer that in the otolith organs the normal stimulus is the pressure due to the weight of the otolith resting on the sensitive macular epithelium; when the position of the head is changed the pressure is shifted to a different part of the macula and a different set of impulses is sent to the muscle groups concerned. This conception has been greatly strengthened by the work of Delage, Kreidl and others on the otocysts of invertebrates. But as I have shown in the preceding section stimulation experiments show with the utmost clearness and regularity results which are exactly the reverse of those which should follow if the pressure theory were true. In describing these experiments I have been repeatedly stopped to answer the question, "Don't you mean 'to the right' when you say 'to the left'?" or, "Don't you mean 'backwards' instead of 'forwards'?" When the normal animal is rotated around its longitudinal axis, to say 30° to the right, the right eye goes up and the left eye goes down. When the body is in this position the weight of the otolith in each ear must be shifted to the right. But when the right side of the otolith is pressed upon or when the cotton is

pulled to the right exactly the opposite movement of the eyes results. If as commonly believed, the stimulus is the pressure due to the weight of the otolith, and if that pressure, shifted to right by inclining the body to the right acts by stimulating more strongly the epithelium on the right hand side surely the artificial application of pressure should produce the same result but just the reverse actually happens. I believe that the actual process is as follows: When the right side of the otolith is pressed upon it is displaced to the left just as one saucer standing in another is displaced to the left when one pushes straight down on its right hand margin. This, then, is the same displacement as that which occurs when the body is tilted to the left. It is *not the pressure* but the *displacement* due to the weight of the otolith which brings about the normal stimulus. It is the *direction* of the *displacement* which determines the direction of the resulting compensatory movement. I have ventured to suggest that the displacement gives rise to differences of tension which act on the sensory structures in a manner analogous to the effects of different tensions on the vagus endings in the lungs. It will be seen in the following section that this wholly unexpected result is in accord with the conclusions which I had previously reached in regard to the mode of stimulation of the ampullæ.

IV. THE MECHANISM OF THE PHYSIOLOGICAL STIMULATION OF THE AMPULLÆ

An adequate discussion of the enormous literature of this subject would far exceed the limits of this paper. Nearly half a century ago Mach, Breuer and Brown almost simultaneously published papers suggesting that each canal functioned for the recognition of rotational movements in its own plane. Roughly stated the assumption was that rotation of the head in the plane of any canal would tend by the inertia of the fluid within the canal to produce a current in the direction opposite to that of the rotation. In the popular literature and in many of the text-books a favorite statement of the theory is about as follows: Each rotation of the head in the plane of any canal causes through the inertia of the endolymph a current in the canal in a direction counter to the rotation. The hair cells of the ampullæ stick out like paddles and are deflected in the direction of the current. The bending of the hair cells exerts pressure on the nerve endings and produces the stimulus. Mach, however, was too good a physicist to believe that a current could be produced under the conditions existing in the semicircular canals. He found that water placed in a glass model of the dimensions of a human semicircular canal showed no perceptible current when rotating at a reasonable speed. He affirmed on theoretical grounds that rotation could cause a pressure but denied the possibility of an actual current. Breuer (1899) also found on anatomical grounds that the theory in this form is not tenable, for the hair cells do not project into the endolymph, but are embedded in the gelatinous mass of substance forming the cupula. In more recent years Rossi (1914) has constructed a model of the dimensions of a human canal and has been able to demonstrate some movement of the contained liquid when rotated; but the rate of rotation necessary to produce visible movement is far beyond the order of magnitude of the rate giving a distinct physiological reaction. Moreover, according to the very beautiful anatomical work of A. A. Gray (1907–08) the semicircular canals in the squirrel and the rat have each a diameter only 1/5 as great as in man. These animals show no inferiority in labyrinthine reactions. In order to form a satisfactory demonstration it would be necessary to make the external diameter of the tube in the model 0.25 mm. I have found (1912) that in the horned lizard, *Phrynosoma*, rotation at an angular velocity so slow as a movement through 45° in 8 seconds caused a distinct labyrinthine reflex. Under these circumstances a current is unthinkable.

Direct experiment on the canals is more to the point than the foregoing theoretical considerations. Loeb (1891) cut through or excised portions of the canals in the dogfish

and found that no disturbance of righting reactions resulted. Ewald (1892) plugged and cut the canals in the pigeon without throwing them out of function.

I have ligatured, cut and plugged the canals in the dogfish (1910) without in the least disturbing their functions. But I have put the canal current theory to a more decisive test (1919). In the dogfish the compensatory movements to rotation in the horizontal plane are mediated only by the ampullæ of the horizontal canals, and each acts only for rotation toward its own side. If one horizontal ampulla, say the left, is removed, rotation to the right around the dorsoventral axis causes both eyes to deviate to the left, but rotation to the left has no effect. I exposed a right horizontal canal for nearly its whole length, cut it through as near as possible to its posterior connection with the vestibule, then without injuring its connection with its ampulla I raised it up and fixed it in the vertical plane at right angles to the longitudinal body axis. It is evident that with the canal in this new position rotation in a horizontal plane could not cause a current in its endolymph. But rotation to the right around the dorsoventral axis actually caused both eyes to deviate to the left, while rotation to the right (or left) around the longitudinal axis, that is in the plane of the new position of the canal, did not cause such a movement. It is evident that under the conditions of the experiment rotation in a horizontal plane could not possibly produce a current in the canal, and hence the stimulation must have been produced in some other way.

Since no further consideration need be given to the idea that the excitation on rotation is due to currents in the semicircular canals, we may briefly consider other possible causes. These might be effects due to (1) the inertia of the mass of fluid in the vestibule, or (2) due to the inertia of the ampullar contents, or (3) due to the inertia of the sensory cells themselves. The second and third of these possibilities are eliminated by the fact that when the membranous connection of the utriculus has been cut off the compensatory movements to rotation in the horizontal plane are entirely absent although the motions can be as easily elicited as ever by mechanical stimulation.

Since the transection of the utriculus abolishes the reflex it is clear that the utricular (and possibly the saccular) structures are an essential part of the mechanism. It is to be noted that the direction of rotation which acts as a stimulus to any canal is that which carries foremost the side of the ampulla bearing the crista. In looking over the large number of figures given by Retzius and by A. A. Gray I find no exception to this rule. The mouths of the canals at their ampullar ends are so connected with the vestibular parts of the membraneous labyrinth that the inertia effect of the mass of liquid (endolymph and perilymph) in the vestibule must cause an increase of tension on the part of the ampulla bearing the crista when a rotation is made in the direction in which the crista leads. A careful examination of the anatomical relations will show that even if it were possible for the inertia effect of rotation to cause a movement of liquid in the canal and thus exert a pressure on the cupula (the hair cells of course could not be acted upon directly), a much greater effect must be produced on the membranous structures in the vestibule. The relatively large mass of liquid in the vestibule with its proportionally small surface area exposed to the friction of the walls must show more inertia effect during rotation than the small amount of liquid in the canal with its proportionally large area of contact with the canal walls. The membranes which form the sacculus and utriculus are virtually stretched through the mass of liquid in the vestibule and must necessarily be put under tension when any rotational movement is given to the liquid.

If the above conception is the correct one it should be true that change of tension and not change of pressure should act as the stimulus. I had previously shown by experiments on *Phrynosoma* (1912) that the pressure due to centrifugal force has nothing to

do with the excitation. When the animal was placed with its head 25 mm. from the center of rotation it required no greater rate of rotation to act as a stimulus than when the head was 300 mm. from the center. The centrifugal force in the latter position is 12 times as great as in the former, but the angular velocity and hence the torsion effect was the same in the two positions.

Convection currents due to a difference in temperature on the two sides of the vestibule could much more conceivably occur in the liquid of the vestibule than in the canals. The nystagmus movements described by Högyes as a result of irrigating the external ear of man and many animals with hot or cold water and the change of character of the nystagmus by change of position of the head can best be accounted for by the changes of density of the liquid in the vestibule. The reliability of Bárány's use of these phenomena for diagnostic purposes is not affected by the acceptance of this view, but only his unscientific explanation must be abandoned.

I wish in closing to draw attention to the fact that a survey of all the experimental work on the labyrinth leads to the conclusion that the stimulation of the vestibular structures and of the sensory endings in the ampullæ depend upon the same principle, namely the effects of changes of relative tensions. How the change of tension excites the nerve endings and what part if any the hair cells play in the process still remains wholly outside the field of experimental investigation.

S. S. MAXWELL

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REFERENCES

Breuer, J.
1899. Ueber die Bogengansampullen. *Zentralblatt für Physiol.*, 13: 750.

Gray, Albert A.
1907–8. The labyrinths of animals. London, J. A. Churchill.

Kubo, Ino.
1906. Ueber die vom N. acusticus ausgelösten. Augenbewegungen. II. Versuche an Fischen. *Arch. f. d. ges. Physiol.*, 115: 457.

Lee, Frederic S.
1893. A study of the sense of equilibrium in fishes. *Journal of Physiol.*, 15: 311.

Loeb, J.
1891. Ueber Geotropismus bei Thieren. *Arch. f. d. ges. Physiol.*, 49: 175.

Maxwell, S. S.
1910. Experiments on the functions of the internal ear. *Univ. of Calif. Pub. in Physiol.*, 4: 1.
1912. On the exciting cause of compensatory movements. *Am. Jour. of Physiol.*, 29: 367.
1919. Labyrinth and Equilibrium. I. A comparison of the effect of removal of the otolith organs and of the semicircular canals. *Jour. of Gen. Physiol.*, 2: 123.
1920*a*. Labyrinth and Equilibrium. II. The mechanism of the dynamic functions of the labyrinth. *Jour. of Gen. Physiol.*, 2: 349.
1920*b*. Labyrinth and Equilibrium. III. The mechanism of the static functions of the labyrinth. *Jour. of Gen. Physiol.*, 3: 157.

Parker, G. H.
1909. Influence of the eyes, ears and other allied sense organs on the movements of the dogfish, *Mustelus Canis* (Mitchill). Bull. Bureau of Fisheries, 29: 43.

Rossi, G.
1914. Di un modello per studiare gli spostamenti della endolinfa nei canali semicircolari. *Arch. di Fisiol.*, 12: 349.

MEETING OF THE GENETICISTS INTERESTED IN AGRICULTURE

IN conjunction with the meetings of the American Association for the Advancement of Science and affiliated societies in Chicago an informal gathering of instructors and investigators of genetics related to agriculture was held December 28th at the University of Chicago. Some thirty-five representatives from fifteen Agricultural Colleges and Experiment Stations, the United States Department of Agriculture and other institutions were present. Unfortunately the impossibility of getting the final notices out until very late prevented a number of others from attending. The purpose of the meeting was to discuss such topics of mutual interest at this time as

departmental organization, the place of genetics in the curriculum in agricultural colleges and cooperation in genetic investigations.

In order to open up the subject and start the discussion the above topics were assigned in advance by Professor L. J. Cole, of Wisconsin, who was largely instrumental in bringing about the meeting. In the carrying out of this plan Professors J. A. Detlefsen, Illinois, and R. A. Emerson, Cornell, spoke on organization. In their talks and the discussion which followed it was shown that in many institutions the instruction and research in genetics are scattered about in many different departments with no one person or department responsible for a fundamental course in genetics. In other institutions some genetics is taught in all departments with the emphasis laid in some one department, while in other institutions a separate department of genetics has been established which assumes all responsibility for genetics although other departments may give some special courses and carry on particular lines of research where the staff is interested and well fitted to do such work. All were agreed that a fundamental, general course of genetics should be required before taking up any applied courses in breeding, but in what department that course should be given is a secondary matter to be determined by existing conditions. Many thought it to be desirable for the teaching staff to keep in touch with applied problems of genetics by carrying on investigations of a practical nature although it would be unwise to limit either the theoretical or applied research to a single department of genetics as the outcome of such experiments depends so largely on familiarity with the material worked with and individual interest in particular problems.

In order to bring the general conclusions to the attention of the authorities of the agricultural colleges and experiment stations a committee was appointed to draw up a statement which would embody in a general way the consensus of opinion of this meeting in regard to the matter of departmental organizations. The following resolution was prepared and adopted:

> As far as consistent with present organization in agricultural colleges a single department of genetics, prepared to handle the elementary and advanced courses of general genetics and to direct the investigational work on the basic principles of genetics, has certain practical advantages in that such an arrangement: (1) simplifies administration and prevents unnecessary duplication; (2) identifies and gives standing to the subject of genetics in the curriculum; and (3) unifies instruction and research. Such a department should not attempt to control all the investigational work in specialized subjects on either the applied or theoretical problems of genetics but would be able to cooperate in every way possible to advance the outcome of such investigations.

The place of genetics in the agricultural curriculum was discussed by Professors E. B. Babcock, California, and S. A. Beach, Iowa. In their presentations and in the discussion which followed it was stated that it is theoretically desirable that a general course in genetics should be required of all students of agriculture but that in practise it is not always possible to do this. Most institutions require genetics of students taking certain courses, particularly those concerned directly with plant and animal production. In other institutions genetics is optional with the student or left to the student advisers. Laboratory work is not always required except of those students who intend to specialize in genetics. A general course in genetics should come as early in the curriculum as possible, usually in the second or third year, and should follow an elementary course in biology or its equivalent and precede any of the courses in applied genetics. This would seem to be self-evident but as now practised this is not always the case. There should, furthermore, be only one such elementary course, in whatever department given, which should treat of the general principles and lay the foundation for further application to special subjects.

The subject of cooperation in genetic investigation was discussed by Professor M. J.

Dorsey, Minnesota, who emphasized the close relationship of genetic investigations on applied problems with other sciences, cooperation being particularly necessary to secure the greatest results. All who entered the discussion of this topic thought that cooperation should not go on so far as to attempt to direct another's research and that the success of any cooperation of this kind is limited by the mutual confidence of the workers.

At the close of the meeting it was agreed that no permanent organization should be formed but that informal meetings such as this should be arranged for whenever desirable. Professor L. J. Cole, who was elected chairman of the meeting, was voted to act as secretary *ad interim*.

D. F. JONES,
Secretary pro tem.

NATIONAL PARKS[1]

WHILE a small number of scientific societies were represented, the conference was well attended, especially by those interested in natural parks for recreation purposes. Their aim is to secure more parks and protect existing ones. Very few of the existing parks and preserves are free from liability to extensive modification through recreation activities, scientific forestry, fires, or exploitation. Even the National Parks must be watched and defended against external aggression. There are now only a few areas aside from the National Parks which have been set aside with the intention that they should be left in a natural state. Most areas have been and probably will continue to be set aside primarily as recreation parks, or as forest preserves. The main business of those interested in areas to be held in an original state, must of necessity be to get areas set aside within these forest preserves and parks.

The following was made evident by the conference.

1. That the forces interested in the establishment of natural parks and forest preserves for recreation purposes—to make "better citizens through contact with nature" are well organized, and are probably the strongest force operating to secure more parks and protect existing ones.

2. Science has left them quite uninformed of its needs for natural areas and of the practical significance of scientific results which may accrue from study of natural areas. They welcome the idea of biological study as a further argument for natural tracts.

3. They are, however, without constructive plans of management of the smaller tracts which will insure them against destruction from over use as recreation parks. Such plans of management must be based on knowledge of plant and animal ecology which they do not possess.

4. They are engaged in drafting legislation and in advising legislators without the counsel of those interested in preserves for research purposes.

5. It is incumbent upon scientific societies, museums, and universities to organize and to provide funds which will serve the following purposes: (*a*) to place information as to the scientific uses, and scientific management of natural areas, into the hands of those individuals and organizations working for the preservation of natural conditions; (*b*) to make possible the representation of scientific needs before legislative bodies and officials; (*c*) to provide for furthering the wise selection of new areas, and (*d*) to make existing areas accessible to scientists by the publication of lists and guide books.

V. E. SHELFORD

[1] Report of the delegate of the American Society of Zoologists to the National Conference on Parks, Des Moines, Iowa, January 10–12, 1921. This report will be submitted to the American Society of Zoologists at their next annual meeting. —W. C. ALLEE, *Secretary-Treasurer.*

SCIENTIFIC EVENTS

WORLD PRODUCTION OF COAL IN 1920

REPORTS received by the United States Geological Survey indicate that the total output in 1920 was about 1,300,000,000 metric tons. This, although a great increase over 1919, was still 42,000,000 tons short of the output in 1913, the last year before the Great War. The

course of production during the last decade is shown in the following table. The unit of measurement, it will be noted, is the metric ton, which will be most easily remembered by American readers as roughly equivalent to the gross ton of 2,240 pounds. The fluctuations in world coal supply, if expressed as index numbers, taking the output in the year 1913 as equal to 100, become as follows:

1910	86	1916	97
1911	89	1917	100
1912	93	1918	99
1913	100	1919	86
1914	90	1920	97
1915	89		

These figures are necessarily in part estimated, for official statistics are slow in coming in and for certain countries of eastern Europe—notably Russia—even unofficial data are lacking. The figures are presented as tentative and subject to revision. As official reports are available for 92 per cent. of the world's output, the margin of error in the total probably does not exceed 1 or 2 per cent.

In comparing the 1920 output with that of the years before the war it must be remembered that the world's consumption of coal normally increases by leaps and bounds. The average rate of increase in the 20-year period preceding August, 1914, was 38,000,000 tons. Of course the waste and disorganization of the war have reduced the consuming capacity of many countries, but in other countries, notably the United States, requirements have been increasing at a rate greater if anything than before the war.

The present rate of production in the world is the resultant of conflicting forces; the decline in the war-torn countries is being offset in part by an increase in regions remote from the battlefields. In the belligerent countries of Europe the war cut heavily into production. Sometimes the cause of the decline was physical destruction of the mines, as in France; sometimes it was the drain upon the manpower of the nation; sometimes it was merely the economic disorganization and disruption of normal trade which attended the war. In France the 1920 output (excluding the Saar and Alsace-Lorraine) was 46 per cent. less than that of 1913; in Great Britain the decline was 20 per cent.; in Germany (also excluding the Saar and Alsace-Lorraine) the output of bituminous coal decreased 24 per cent., a decrease which was in part, however, offset by the increased production of lignite. In eastern Europe the old Austro-Hungarian empire, Russia and the Balkans, the breakdown caused by the war was even greater than in western Europe, and the decline in output proportionately large. Of all the major European belligerents only Belgium had in 1920 practically reattained the pre-war rate of production.

While in 1913 Europe led all the continents as a producer of coal, contributing 54 per cent. of the world's output, in 1920 she had yielded first place to North America and her share of the world's total had shrunk to 46 per cent. The largest factor in filling the void caused by the war in Europe was, of course, the United States. Our production increased from 38.5 per cent. of the total for the world, in 1913, to 45.1 per cent. in 1920. In that year our seaborne exports of coal were 22,500 net tons, five times what they were in 1913.

TOP MINNOWS AS YELLOW FEVER ERADICATORS

According to *The Fisheries Service Bulletin* the success which has attended the use of the top minnow (*Gambusia*) in eradicating malarial mosquitoes in various parts of the United States has led to the employment of the same fish in combating an incipient epidemic of yellow fever at Tampico, Mexico.

Dr. A. R. Stubbs, of the Standard Oil Co., who visited the Washington office in March, reported that cases of yellow fever appeared at Tampico during the past summer, and there was every indication of a serious epidemic, as the conditions for the spread of the disease among the natives were most favorable. In addition to numerous outlying ponds, pools, sloughs, and marshes in which mosquitoes breed, all of the native houses have open barrels or other receptacles con-

taining rain water that is used for domestic purposes and is the only supply of fresh water that the natives possess.

At the outset the oil interests organized an antimosquito campaign, conducted through a committee headed by Dr. Stubbs. About 600 men were constantly employed in oiling the ponds and other open waters, and also the receptacles in which the natives keep their water for domestic purposes. The use of crude oil on the water required by the natives for drinking and cooking naturally caused much dissatisfaction.

After some months, when an official of the U. S. Public Health Service visited Tampico, he mentioned the value of *Gambusia* in the antimosquito work of the Public Health Service and Bureau of Fisheries, and suggested that this fish might be available for the yellow-fever campaign at Tampico. A search was forthwith made and *Gambusia* was found in abundance in the vicinity. Since December 1 the top minnow has entirely replaced crude oil as an eradicator of mosquito larvæ, the natives are much pleased at the change, and the reduction in the expense has amounted to $3,000 weekly.

THE NATIONAL BOTANIC GARDEN[1]

FIVE years ago the commission of fine arts was requested to investigate and report as to the possibilities of relocating the existing Botanic Garden, at the foot of the Capitol, from its present restricted area to a more suitable site, and after surveying carefully several suggested sites in the District of Columbia decided upon Mount Hamilton and the land adjacent as the most suitable location for a National Botanic Garden. A year ago at a hearing before the joint congressional committee on the Library the plan was again thoroughly discussed. The highest scientific and botanical authorities in the country attended the hearings, and not only indorsed the site as being in location, area, variety of soil, elevation and accessibilty most adaptable for a National Botanic Garden, but asserted also the great need for such a garden as would be comparable with those of other great countries of the world.

Once the National Botanic Garden has been established and developed, it would be one of the great sightseeing places of Washington, which would be visited by thousands of persons annually. The Zoological park is 3.50 miles and Arlington National Cemetery 4.50 miles from the Capitol, yet each is visited by thousands of persons each week. The daily average attendance at the Zoological Park is 6,108, from 20,000 to 40,000 on Sundays and more than 2,000,000 for the year. The Mount Hamilton site is only two miles northeast of the Capitol, and is accessible by lines of street cars. In addition the National Botanic Garden would be a place where thousands of school children of the city could make a study of plant life and the garden would continually be a place of enjoyment for residents of the city. The Mount Hamilton site is on the main highway between Baltimore and Washington, one of the main approaches of the city. A boulevard would lead through the grounds along which a countless number of persons would travel each year in order to see the garden.

[1] From *The Washington Post*.

MEDICAL PRIZES

THE *Journal* of the American Medical Association announces the following prizes:

The Mörsel Foundation offers a prize of 10,000 marks for the best work on the etiology, diagnosis or treatment of cancer, representing important progress. A second prize of half the amount will be given for the second best work. Competition is open till October 1, 1922. Competing articles are to be sent to the director of the Institute for Experimental Cancer Research at Heidelberg. The competing works must be in German and must have been published between January 1, 1921, and October 1, 1922, or be ready for publication when presented.

The Royal College of Physicians of Edinburgh announces the Parkin Prize of £100, open to competitors of all nations, for the best essay "On the Effect of Volcanic Action in the Production of Epidemic Diseases in the

Animal and in the Vegetable Creation, and in the production of Hurricanes and Abnormal Atmospheric Vicissitudes." Particulars regarding the conditions of the contest may be secured from the secretary, Dr. J. S. Fowler, Edinburgh.

In honor of Dr. Charles Lester Leonard who died in 1913 a martyr to research with the roentgen ray, the American Roentgen Ray Society offers a $1,000 prize for the best piece of original research in the field of roentgen ray, radium or radioactivity. The competition is open to any one living in the United States, or its possessions, Canada, Mexico, Central and South America and Cuba. The research work must be submitted in writing in the English language not later than July 1. The winner will read his paper at the annual meeting of the society in September. Dr. Henry K. Pancoast of the University Hospital is a member of the committee in charge of the competition.

THE COMMITTEE ON PHYSIOLOGICAL OPTICS OF THE NATIONAL RESEARCH COUNCIL

Under the auspices of the Division of Physical Sciences of the National Research Council, there has recently been formed a Committee on Physiological Optics consisting of

Professor Adelbert Ames, Dartmouth College,
Professor W. T. Bovie, Harvard University,
Dr. P. W. Cobb, Nela Research Laboratory,
Mr. L. A. Jones, Eastman Kodak Company,
Dr. W. B. Lancaster, Boston,
Dr. P. G. Nutting, Pittsburgh,
Dr. I. G. Priest, Bureau of Standards,
Professor J. P. C. Southall, Columbia University,
Dr. L. T. Troland, Emerson Hall, Harvard University, Cambridge, Mass.,
Professor F. K. Richtmyer, Cornell University, Chairman.

This committee recently held a meeting in New York for the purpose of organization and discussion of the problems before it. The diversity of present theories of vision was thought to be due in large part to the circumstance that the workers in the sciences contributory to visual phenomena, such as physics, physiology and psychology, seldom, if ever, get together to talk over problems of mutual interest and to get each other's viewpoint.

To facilitate an interchange of ideas among the various groups of workers, the committee voted to request the Optical Society of America to form a Section on Vision. Such a section has been authorized by the society and the first meeting will be held in Rochester in October, 1921. It is hoped that all those interested in the pure or applied science of vision, such as physicists, physiologists, psychologists, ophthalmologists, photochemists, illuminating engineers, etc., will join the new section and will take an active part in its work.

The committee will also immediately make a survey of present research in progress. Later will be issued a report on the present status of physiological optics with some outstanding problems for research.

SCIENTIFIC NOTES AND NEWS

At the annual dinner of the National Academy of Sciences on April 26, the following medals were presented: To Dr. Charles D. Walcott, secretary of the Smithsonian Institution and president of the Academy, the first award of the Mary Clark Thompson Medal for distinguished achievement in geology and paleontology. To Albert I., Prince of Monaco, the Alexander Agassiz Gold Medal for contributions to the science of oceanography; to Dr. P. Zeeman, of Amsterdam, Holland, the Henry Draper Gold Medal for eminence in investigations in astronomical physics; to Rear Admiral C. D. Sigsbee, U. S. N., retired, the Agassiz Gold Medal, the same as the medal to the Prince but awarded one year later, for eminence in investigations in oceanography; to Dr. Robert Ridgway, the Daniel Giraud Elliot Gold Medal for his studies of the birds of North America, and especially in recognition of Part 8 of his "Birds of North and Middle America"; to Dr. C. W. Stiles, the Gold Medal for eminence in the application of science to the public welfare, in recognition of his work on the hook worm disease.

THE June issue of the *Medical Review of Reviews* will be a special radium number, dedicated to Mme. Curie. The issue will consist exclusively of articles on radium and its uses.

As Professor A. Netter of the University of Paris soon reaches the retirement age, his friends and pupils are planning to present him with a testimonial plate.

EIGHT professors of the College of Agriculture of Cornell University will be on sabbatic leave next year. They are Professors Herbert H. Whetzel, George W. Cavanaugh, Ralph S. Hosmer, Karl M. Wiegand, Arthur B. Recknagle, Blanche Hazard, Anna B. Comstock and Earl W. Benjamin. Professor Whetzel will organize a plant pathology service for the Bermuda Islands. Professor Hosmer will make a study of the forests of England, France, Switzerland, Sweden and Norway. Dr. Benjamin will act as general manager of a poultry-producing firm in New Jersey, making efficiency and cost studies.

THE department of medical zoology of the school of hygiene and public health of the Johns Hopkins University has recently arranged to send during the summer of 1921 an expedition to Porto Rico for the purpose of studying the malaria problem and other problems involving disease-producing protozoa and their vectors. Dr. R. W. Hegner will devote his time especially to the study of the malarial organism and other blood-inhabiting protozoa and to the intestinal protozoa, and Dr. F. M. Root, who will accompany him, will make a survey of the mosquitoes, fleas and other distributors of pathogenic microorganisms.

WALTER L. HOWARD, professor of pomology in the University of California, now in charge of the new Deciduous Fruit Experiment Station at Mountain View, California, has been granted a year's leave of absence to make a study of root stocks for deciduous fruits. Accompanied by his family, he will sail from New York to Europe on June 25, going direct to Angers, France. The field of study will include France, Italy, Spain and England.

UNDER the auspices of the General Electric Company and Union College, Professor F. K. Richtmyer, of the Department of Physics at Cornell University, has given in Schenectady, during the present academic year, a course of lectures on modern physical theories.

ON April 7, Professor Edward Kasner, of Columbia University, lectured on "Einstein's theory of gravitation" at the College of the City of New York. Professor Einstein attended and took part in the discussion.

DR. GEORGE H. PARKER, head of the department of zoology at Harvard University, is in residence at Pomona College as Harvard exchange professor, from April 11 to May 6, giving two courses of lectures, on "The origin of the nervous system" and "Smell, taste and allied senses."

PROFESSOR HARRIS J. RYAN, of Leland Stanford Junior University, spoke on April 20 before the Physics Club of the California Institute of Technology and the Mount Wilson Observatory on: "High voltage phenomena encountered in the study of the insulation requirements for the proposed 220,000 volt power transmission lines."

ON April 23 Dr. Dayton C. Miller, head of the department of physics, Case School of Applied Science, and secretary of the American Physical Society, gave an experimental lecture upon "Photographing and analyzing sound waves."

DR. HARVEY R. GAYLORD, director of the New York State Institute for Research in Malignant Diseases, and Dr. Charles Cary, of Buffalo, left for Germany on April 23 to investigate methods developed in Germany for applying X-rays to cancer.

JAMES ZETEK, formerly entomologist to the Panama Canal, has been appointed specialist in tropical insects with the Federal Horticultural Board, U. S. D. A., in charge of the temporary field station at Ancon, Canal Zone, Panama.

DR. PAUL E. KLOPSTEG, who has been connected with the sales and advertising department of Leeds and Northrup for several years,

has recently accepted a position with the Central Scientific Company of Chicago as manager of development and manufacturing.

Professor James H. Leuba, of Bryn Mawr College, who is to be abroad during the next academic year on sabbatical leave, has been invited to give five lectures at the Sorbonne in the Fall of 1921, under the auspices of the Institut de Psychologie. His subject will be the psychology of religious mysticism. He is also to deliver a series of lectures at Kings College, London.

The Columbia Chapter of the Society of Sigma Xi announces a lecture on "Progress in physics in the last decade," by Michael Idvorsky Pupin, professor of electro-mechanics. This lecture which was given on the evening of May 4 is the first of a proposed series of annual lectures on the Progress of Science.

An address on "The spirit and method of research in agriculture" was given by Dr. E. W. Allen, of the office of experiment stations, at the college of agriculture, at the Ohio State University, on April 15.

Dr. Arthur Gordon Webster, head of the department of physics at Clark University, will sail on May 28 for London, where he will deliver a lecture on "Researches on Sound," before the Royal Institution, on June 10.

Dr. Frank Schlesinger, director of the Yale Observatory, will deliver an address before the Yale chapter of Sigma Xi on "The distances of the stars," on May 10.

Dr. C. G. Abbot, assistant secretary of the Smithsonian Institution, delivered an address before the Washington Academy of Sciences on April 22 on "The solar constant observing stations of the Smithsonian Institution."

Dr. George Frederick Wright, known for his contributions to geology especially glacial period, and professor emeritus of the harmony of science and religion at Oberlin College, died at Oberlin on April 20, aged eighty-three years.

The establishment of the Chemical Warfare Service at Edgewood Arsenal, Edgewood, Maryland, will appoint fifty chemists as soon as suitable men can be secured. The United States Civil Service Commission has announced that until further notice it will receive applications for these positions in the following grades: Chemist at $3,000 to $5,000 a year, associate chemist at $2,000 to $3,000 a year, and junior chemist at $1,400 to $2,000 a year. Promotion from the lower to the higher grades will depend upon demonstrated ability and the needs of the service. The examination announcement states that there are opportunities for employment in fifteen specialties of chemical science. Full information and application blanks may be obtained by communicating with the United States Civil Service Commission, Washington, D. C.

The inadequacy of the appropriation to the Bureau of Fisheries for scientific work has made necessary a reduction in the number of projects to be pursued by that bureau during the next fiscal year and will necessitate keeping the Woods Hole, Massachusetts, laboratory closed during the summer. Therefore, no applications for the use of tables during the coming season can be approved.

A communication from J. Parke Channing of New York, chairman of the American Engineering Council's Committee on Public Affairs, has been placed before President Harding and representatives of the council have been advised that the president is considering the recommendation that an engineer be placed on the Interstate Commerce Commission with other recommendations for appointments to the three vacancies. A supplementary communication was also submitted to the president naming six engineers with qualifications for this appointment in the hope that such list would be useful to him. In representations to the president, the council is also acting for the American Society of Civil Engineers, the American Association of Engineers and the American Institute of Consulting Engineers. The American Engineering Council's Committee on Procedure has appointed L. W. Wallace, executive secretary of the council, as its representative on the U. S.

Board of Surveys and Maps. Mr. Wallace succeeds Alfred D. Flinn, secretary of Engineering Foundation, and has been assigned to the Committee on Cooperation. Members of the Advisory Council of the board have been urging the American Engineering Council to aid them in obtaining an adequate program involving a larger appropriation for topographic maps. Congress has asked for an outline of this program and as soon as this is completed the council will decide on the support that can be given.

THE prospect of large lumber operations in South America carried on by interests from the United States is opening a field of promising possibilities to the American forester, and this situation has caused the faculty of the New York State College of Forestry to consider the advisability of adding Spanish to the language requirements of the forestry course. The value of Spanish to the American forester is a reflection of the growing scarcity of forests in the United States and Canada. The consequential high prices of wood products make lumbering in distant countries profitable. South America, according to authorities of the college, presents a new sphere of discovery in wood utilization as there are many species of trees about which little is known regarding their applicability to commercial purposes. The pine forests of Chili and southern Brazil occupy vast areas. The Brazilian Parana pines are said to cover 260 million acres and will produce from five to ten thousand board feet per acre. Restrictive export duties and the lack of shipping facilities have prevented earlier exploitation of these natural resources of South America, but the prodigality of the United States in the use of its forests has overcome these obstacles.

UNIVERSITY AND EDUCATIONAL NOTES

THE College of Agriculture and the College of Veterinary Medicine of Cornell University will receive approximately $1,350,000 from the State as a consequence of the appropriation bill signed by Governor Miller. The College of Agriculture will receive, roughly, $1,250,000, while the Veterinary College, it is estimated, will receive $100,000, which is slightly less than last year's appropriation.

THE North Carolina Legislature has granted the University of North Carolina $925,000 as a two-year maintenance fund and $1,490,000 for permanent improvements for two years.

PROFESSOR GEORGE C. EMBODY has returned to Cornell after spending the period since last September establishing at the University of Washington the first college of fisheries in an American university.

DR. IRA M. HAWLEY, of Cornell University, has been appointed professor of zoology and entomology at the Utah Agricultural College and Entomologist for the Utah Agricultural Experiment Station. Sherwin Maeser, Ph.D., University of California, has been appointed associate professor of chemistry at the college.

DR. LEWIS KNUDSON, of the department of botany of Cornell University, has gone to Spain to assist in establishing departments of plant physiology in the Universities of Madrid and Barcelona.

DISCUSSION AND CORRESPONDENCE

PALEOBOTANY AS VIEWED BY TWO GEOLOGISTS

IN the current April *American Journal of Science* appear two papers reciting the larger stratigraphic and faunal evidence bearing on climate in time. Professor A. C. Coleman in the first of these lectures cites especially Dr. Knowlton's views of all-tropic ancient climates thus:

> Part I. of Dr. Knowlton's paper rouses enthusiasm with its splendid array of forests mostly tropical from all parts of the world culminating in the Eocene flora. His account of the vegetation of the past confirms and heightens the impression left by paleozoology that during the greater part of the world's history temperatures have been genial even in the far north and far south where

frigid climates now reign. Annual rings are rarely found in the trees, and only once before the Pleistocene is a period of severe cold admitted in the early Permian time of glaciation; and then the cold period was "probably of short duration," and did not affect North America, Europe or northern Asia.

It is further observed that while few references to periods of cold or drought in the world's history are found in paleobotany, "mild and moist periods are tremendously emphasized," and intervening periods of drought and cold "slurred over, or entirely unrecorded."

It is not surprising, then, that the evidence for aridity and cold during several periods of the earth's history should make little impression on a paleobotanist!

In somewhat similar inference or vein, Professor Charles Schuchert follows with several pages on climatic evolution. To Coleman's brief consideration of the more readable phases in the evidence for desert conditions seasonal variations, and ice ages in the past, Schuchert adds the Blackwelder view that a study of the color phases and stratification of the Alaskan sedimentary series indicates a more or less persistently cool moist climate throughout the known geologic history of Alaska. And the more or less provable fact is emphasized that there is usually "a dearth of plant evidence for the climatic conditions during the early and late parts of the many periods when the continents were largest, highest and most arid."

For several years I have called attention to the remarkable series of Rhätic plant localities in Argentina which strongly suggest a climate like that of to-day. And too, the shales in which these plants occur are highly laminated [seasonally so]. But in such instances, which may be depended upon to multiply, the paleobotanist must yet find the fuller means of proving the presumption of cold and aridity from plant types, however insistently others may ask immediately coordinated proof. Similarly it was stated in Science several years ago that:

There is a very small record of the upland vegetation of past times; although the enormous extent of the unknown upland record could not be surmised so long as the alternate emergence and subsidence of the continental areas remained wholly unmapped. Yet it appears that the high upland and polar, and not the tropic or coastal fringe plants have long included the great majority of plastic forms; and it is certain that upland and polar forms moved forward during the periods of continental emergence closing the geologic epochs, and were least liable to extinction during medial subsidence. That is to say we know best the aplastic coastal fringe forms with a broken record.

Again it was stated (Vol. II., p. 238, American Fossil Cycads):

Almost invariably from the Devonian on, it has been mainly xerophyllous lacustrine or swamp types which form the great bulk of fossil plants. Even the 3,000 species of Carboniferous time afford only a one-sided picture of the specialized coal swamp floras; no glimpse is had of contemporary mountain or upland florules.

Furthermore the notion that the tepid climates of the older botanists and zoologists have no basis (Berry), and are not sustained by the long studied invertebrate record, only finds a more insistent expression in recent text books. It goes back to Leopold von Buch, and received elaboration by Neumayr. It finds so far as elements go mention in Dana. It was stated to me in pretty hard and fast form in the field as a beginning student, by an old teacher, A. von Könen, twenty-eight years ago. And any one who takes the trouble to read a contribution I brought out in 1903, on the rôle of polar climates in evolution, then a sort of philosophic study, can well understand that the ideas of the real character of sediments and the indicators of seasonal change which are quite in entirety of more recent date, would have been "old grist" for the polar mill.

As a main objective, let me try to explain in a few brief paragraphs for the sake of both botanists and geologists the nature of the paleobotanic crux.

Primarily the Cretaceous floras looked tropical, and it has been difficult to read anything else into them. If it can be done it will require long and elaborate quantitative study of the phytologic factors. It would however be early to say there are no cold scrub forests in the lower Cretaceous, and I give some attention to this subject in the current April number of the *American Journal of Botany*. Then at the other end of a long record stood juxtaposed the dank coastal fringes of coal plants; whence the long series of the Permian, Triassic and Jurassic, found their more obvious antecedents in warm climates and seemed to terminate in such. The ginkgos were long almost the only element suggesting interruption to the all-tropic landscape, with the fact that they must be a very great phylum, hidden. But with the cycads dominant and certainly tropical, there was no *open sesame* to a broader vista for the paleobotanist.

Now it was at this point that Nathorst and Wieland, using the words of the excellent University of Glasgow historian of botany, "began to learn something about the cycads." It was found that these had flowers with the possibility of all the sex variation seen in dicotyls, and stems with generalized structure. A great Cycadophyte leaf series was discerned resting under more than a suspicion of affinity to the forerunners of the angiosperms. And presently it was found that the cycadeoid types were in great numbers microphyllous, and that they crossed over into small fern-like leaves called *Tæniopteris*, etc. Next the paleobotanists seemed as if by common consent to see side by side with the ever lengthening cycadeoid record a great ginkgoid phylum. Within but a few fortunate years of investigation types of scrub, for such many of the cycadeoids surely are, and forest elements with the capacity to live in varied climates, could be pointed out with some degree of safety.

But as a bare half dozen invertebrates can not firmly set the age of the "Cannonball shales," limited series of animals and of plants of unfixed affinity, can make neither a summer nor a winter. And so the difficulties which beset the work on fossil plants must be met serially.

Meanwhile as paleobotanists we are peculiarly indebted to Dr. Knowlton for his splendid Philippic on tropic climates. It was well that it should appear in this time of rapid accumulation of new facts, at least as a warning against the grave danger of an overburden of inference in the guise of proven fact. Even that big and valuable word *diastrophism* might suffer. And the aggrading of the continents, with their reappearance, mountain bulwarked as regularly as Chladni figures, might fail of demonstration. The Knowlton defense has already functioned in bringing out the two accentuations of the value of the physical and paleozoologic factors herein noted. Yet, the lower-most Cretaceous floras of the mid-west are not truly tropic. We may doubt if there is a single North American dicotyledonous flora, unless it be that associated with the Vicksburg Oligocene, that by any possibility merits the term tropical in a strict sense. "Many of the floras indicate warmer or wetter conditions than now prevail in correspondent latitudes; but most are far from tropical."

All evidence must eventually be coordinated, and the paleobotanists will lay ears to the rocks. To use exactly the witticism of Voltaire, let our *conchiferous* brethren be reassured.

G. R. WIELAND

HAVE BIRDS AN ACUTE SENSE OF SOUND LOCATION?

THERE can be little doubt that the drum membrane picks up very minute energies in the form of sound vibrations. There can be no question that a certain amount of the energy impinging on the outer surface of the drum membrane passes through it into the air of a cavum tympani. It may also be conceded that energies entering the middle ear area are fairly well dampened out in so far as a reflection back toward the drum membrane is concerned. This is true for the mammals. The bird, however, has but a single middle ear

which is flanked on either side by a drum membrane. The energies transmitted to the air of the middle ear from the deep surface of one drum membrane may pass directly to the deep surface of the other membrane.

The ability to locate a sound may be partly due to its intensity. It may also be due to a differential registration of fundamental and overtones on the two sides. A pure tone may not be located. Overtones are less readily dampened out than fundamentals as Mach's experiments seem to indicate. The relation of the position of the sound source to the head-form and diffraction into the two external canals would therefore play an important rôle in relation to the differential registration of fundamental and overtones. This was I believe worked out in part by Fite of Princeton University.

It would seem that the evidence in birds points not only to a great acuteness in hearing but also to a definite ability in determining the direction of the sound source. This in spite of the fact that birds do not possess the functional auricle of the mammal. If it be true that the sense of location for sound is so well developed in owls, woodpeckers and possibly robins, then a special significance may be attached to a confluence of the middle ear cavities. It may be that a more definite analysis of the fundamental and its overtones is due to a greater efficiency of the two drum membranes applied to a single middle ear.

The writer will appreciate and acknowledge any direct observational data on this problem of the acuteness of hearing in birds and in particular the evidence for the definiteness with which a bird may locate a sound source.

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QUOTATIONS

SCIENTIFIC ORGANIZATION

Professor W. M. Wheeler, a learned and witty American biologist, has recently addressed a genial remonstrance to his scientific fellow-citizens on their devotion to resounding phrases. His remarks deserve a wider application, and are very pertinent to ourselves. The current watchword of the elect, he says, the "highbrow" toast of the moment, is "organization." Wayward, individual pursuit of knowledge is out of fashion. It is distasteful to the bureaucratic spirit of the age, it tends to overlapping of effort, and it exalts personal reputations, possibly and regrettably those of obscure unofficial people. The committee is the thing. The problem must be set, the parts allotted, the results received, edited, and issued by the authority of men sitting round a table. There must be sub-committees and super-committees, joint committees and special committees. How else shall we control genius, encourage mediocrity, and secure "team-work"? How better can science present a respectable front to governments or offer responsible hands for grants-in-aid? A detached individual is an unstable creature; he may die, neglect to report, get off the lines, or make discoveries of a very upsetting kind. A committee is safe; its existence secures continuity and is a guarantee against the precipitate production of uncomfortable truths. But the professor fears that the child product of organization is organizers, and that in elaborating our machinery we forget its purpose. Fortunately, however, mankind is wiser than any of its generations and has a knack of creeping out of the hard shells it continues to secrete. "Organization" is the fad of to-day, and will be as ephemeral as its predecessors. "Culture" was one of these. But "culture" died, and its corrupt body became decadence when, ceasing to be a mental attitude, it became an intonation and a set of opinions. Progress was another; but that has hardly recovered from the shock of the war, which gave us good reason to distrust some aspects of modern civilization. Now even popular preachers find it safe to mock at "progress." The truth is that a conception seldom becomes crystallized in a phrase until it has outgrown its most fertilizing activity. Ideas have their cycle of life; they are born of the great, named by the dull, and killed by common usage.—The London *Times*.

In his presidential address (printed in SCIENCE for January 21 last) before the Zoological Section of the American Association for the Advancement of Science at its Chicago meeting Professor W. M. Wheeler discussed the subject of organization in research as it appears to a biologist, and pointed out some of the dangers attending post-war efforts in this direction. He mentioned the array of instincts, emotions, and interests on which the activities of the investigator depend and the great diversity of mental aptitude which necessarily accompanies the genius for different types of research. Professor Wheeler claims that any organization dealing with research should refrain carefully from interfering in any degree with the free expression of the individual's exceptional aptitudes in his own way. In these days when the amateur in scientific research is passing we need to beware of fettering in any way by government or other interference the activities of the professional scientific man.—*Nature.*

SCIENTIFIC BOOKS

Catalogue of the Coleoptera of America North of Mexico. By CHARLES W. LENG. Published by John D. Sherman, Jr., Mount Vernon, N. Y., 1920. Pp. 470; large octavo.

I don't know how many collectors and students of Coleoptera there may be in the United States—certainly not so many as in several of the European countries, and they are probably not as numerous as the collectors of Lepidoptera. But their numbers will surely increase, and the labors of the present students will be greatly facilitated by the appearance of Mr. Leng's long-expected and thoroughly admirable catalogue.

A good, up-to-date catalogue is a tremendous help and stimulus. The Coleoptera of North America have not been comprehensively listed since the American Entomological Society published Henshaw's list in 1885, more than 35 years ago, and in the meantime large groups have been comprehensively monographed, the scheme of classification has been modified in important particulars, and the names of genera and families have been changed, while the number of described species has increased from a little over nine thousand to a little less than nineteen thousand.

As a result of the publication of this catalogue, the American Coleopterists for the first time in many years know for the moment just where they stand. And what a joy it must be to them! And what a relief it is to all general entomologists! I can imagine the veteran, Samuel Henshaw, himself, sitting in the Director's Office of the M. C. *Z.* at Cambridge, heaving a deep sigh of satisfaction and saying to himself, "Good! My New England conscience is at rest. What I looked forward to years ago is done, and excellently done."

There are catalogues and catalogues. The best ones are more than mere lists, but none the less are based absolutely on the literature and do not reflect too much the individual views of the specialist author. Such is the great synonymical Catalogue of the Coleoptera of the World by Gemminger & Harold, and such is the present catalogue of which we write. Its publication is an event! It is a great big stepping stone!

One like the writer, who knows the Coleoptera only in a general way, is first of all impressed by the excellent make-up of the catalogue. It is printed upon excellent paper; and it can be obtained from the publishers in a very good binding. The topography is of a high character. These, however, while worthy of especial note, are only adjuncts to the main appreciation.

One who is not familiar with the enormous amount of work which has been done by clever men of many countries, will not in the least appreciate the difficulties which Mr. Leng had to encounter. Our conception of the general classification of the Coleoptera has undergone fundamental changes from the LeConte and Horn classification of 1883. Many new characters have been used by subsequent writers, and advanced schemes of classification, based upon these new elements, have been proposed by Lameere in Belgium, Kolbe and Gangl-

bauer in Germany, and Sharp in England, and the general result in the Coleopterological world has been one of some confusion. These systems down to the present time have not been thoroughly adjusted and Mr. Leng had to make a compromise. This difficult work he has done in an admirable manner, as I am told by my expert friends and associates, and in his introduction he has discussed this subject at length. It is an enormous improvement upon previously published North American lists from the fact of this painstaking and enlightening discussion which must have taken an enormous amount of work, as well as from the bibliographical references to original descriptions of new species and genera and the further citation of synopses of monographs that have appeared. The reference system is well handled, and the bibliography, covering more than eighty pages, is remarkably complete and well arranged.

Of course, as one uses the catalogue from day to day in his work, points will be brought out which might suggest improvements, but none have occurred to me in turning the pages. Undoubtedly certain useful changes have occurred to the author and his colleagues in reading the proofs, but in the conditions in the printing trade at this time the expense of alterations is almost prohibitory; and at any rate the defects, if there be any, must be relatively unimportant.

I have talked with several of my associates who are intimately familiar with this group of insects, and all are enthusiastic in their praise of the book. Mr. Leng gives generous acknowledgment of assistance from such authorities as Messrs. Davis, Mutchler, Schwarz, Barber, Bequaert, Schaeffer, Lutz and Böving; and the fact that he has had the assistance of these men intensifies the confidence which we must have in his work.

Although the price of the volume seems high ($10), it is one of those absolutely indispensable things. Every entomologist, including the economic entomologist, must be able to consult it; and all libraries must have it.

The reviewer anticipates with assurance a greatly increased interest in the group of beetles. It is an order of the greatest interest. The specimens are easily collected and are easily preserved. Their compact form and durable structure renders them much more available for collections than any other group of insects. They are much less fragile than the others, and, while they apparently lack the esthetic qualities that attract people to butterflies and the larger moths, their structure is beautifully adapted to their methods of life, and they offer an easy field for the study of certain aspects of broad biological problems.

L. O. Howard

NOTES ON METEOROLOGY AND CLIMATOLOGY

METEOROLOGY AND BALLOON RACING

I am relieved from my anxiety by hearing that the adventurers descended well; . . . that they had perfect command of the carriage, descending as they pleas'd by letting some of the inflammable air escape. . . . Had the wind blown fresh, they might have gone much farther.—Franklin.

The International Balloon Race of 1920.—These words were written by Benjamin Franklin after witnessing one of the first free-balloon flights at Paris, and they are a quaint epitome of the sentiment of free-ballooning, both from the standpoint of the public and that of the pilot. When one has seen the start of a balloon race, with the great silk-skinned bubles rising in the glow of the lowering sun, and the ballast streaming down from the baskets like slender cascades of gold dust, then he may well appreciate the emotions of Franklin in his anxiety for the safety of the balloonists and in his admiration for the skill and judgment required of them. But it is the pilot who can best appreciate the significance of the last statement—"had the wind blown fresh, they might have gone much farther."

No more convincing proof of this can be adduced than that which lies in the distribution of landing points in the International Balloon Race for the Gordon-Bennett cup, which started from Birmingham, Alabama,

late in the afternoon of October 23, 1920. The balloons which departed from Birmingham within half an hour landed at various points along a general line from Mason City, Ill., to North Hero Island, in Lake Champlain. Why did the Belgian DeMuyter land his "glorious *Belgica*" (as he proudly and affectionately calls it)[1] in Lake Champlain, while the American, French and Italian entries were struggling with adverse weather far to the west? It was because DeMuyter found the level where the "winds blew fresh."

Mr. Ralph Upson, the pilot who brought the cup from Europe to America in 1913, has this to say relative to the rôle of meteorology in balloon-racing[2]:

> The history of balloon racing up to the present time shows conclusively that it is taking on more and more of a meteorological character. In the past, races have been occasionally won by mere practical skill in operation of the balloon, but the time when this is possible is rapidly passing, if indeed it has not already passed. In the future, meteorological knowledge instead of being a secondary factor in the assets of a team, will be absolutely the controlling factor.

But the success of DeMuyter did not lie alone in the fact that he is a meteorologist, and that, as he says, he made a careful and critical study of the prevailing types of weather in the United States during the months of October and November: it was also, and largely, because he was able to take advantage of the splendid analyses of the conditions in the upper-air that were made by the United States Weather Bureau observer, Mr. C. G. Andrus, who was detailed to Birmingham to make upper-air soundings for the race. Mr. Andrus has written an article in the *Monthly Weather Review* for January, 1921,[3] in which he discusses the nature of the service rendered to the aeronauts and the weather conditions occurring before and at the time of the race. One of the most striking points in Mr. Andrus' discussion is the agreement between the predicted path of the balloons and the actual paths they followed. A figure is given showing the landing points of the balloons with respect to the predicted path, and it appears that a smooth curve drawn through these points would agree almost exactly with the predicted course. This is remarkable when it is considered that to forecast the probable route of the balloon. it was not only necessary to forecast about two days in advance, but also to take into consideration the probable behavior of the upper winds at all levels during that time. Concerning the flights in general, Mr. Andrus says:

> The balloonists took off from Birmingham just before sunset of the 23d, and floated north-northwestward the first night at elevations averaging 1 kilometer. During the following day they made only moderate speed, mostly toward the north, at various elevations. The following night was the crux; at that time those balloonists who had made the least distance westward had entered the freshening winds of the southeast quadrant of a low-pressure area and rapidly spread away from those pilots who had not gained this advantage. The flying during the last 20 hours was for the most part made in clouds and occasionally in rain, these conditions finally requiring the balloonists to descend.

Upon what data were the conclusions of Mr. Andrus based? In part upon the observations of the Weather Bureau stations, both aerological and surface, these data being telegraphed to Birmingham. He was equipped with apparatus for making pilot balloon observations, also. But what is quite as interesting is that he interpreted these observations in the light of the studies of the Norwegian meteorologist, Bjerknes. The charm of the Bjerknesian interpretation is that it enables one to get a more satisfactory three-dimensional picture of the processes taking place in HIGHS and LOWS than has been usual.

[1] DeMuyter, E., "Comment j'ai gagné la coupe Gordon-Bennett," *L'Aerophile*, December 1–15, 1920, pp. 366–367.

[2] Upson, Ralph H., "Balloon Racing—a Game of Practical Meteorology," *Monthly Weather Review*, January, 1921, pp. 6–7.

[3] "Meteorological Aspects of the International Balloon Race of 1920," pp. 8–10.

It will be worth while, therefore, in these notes to give the salient features of the Bjerknes papers.[4]

The Bjerknes Lines of Discontinuity.—The changes of weather which are associated with the passage of HIGHS and LOWS in the temperate zone are found to depend largely upon a line of discontinuity which marks the boundary between polar and equatorial air. In an individual cyclone, this line of discontinuity consists of the steering line and the squall- or wind-shift, line. Considering as large a portion of the northern hemisphere as possible, this line of discontinuity can be traced from one storm to another so that there is little doubt that it is continuous around the world. North of this line the air is that which "has a low temperature for the latitude, shows great dryness, distinguishes itself by great visibility, and has a prevailing motion from east and north. On the southern side of the line, the tropical origin of the air is recognized by the corresponding signs—its generally higher temperature, its greater humidity, its haziness and its prevailing motion from west and south." This line is called the *polar-front line.*

Sometimes the undulations of the line are such as to cause loops which may represent the cutting off from the parent mass, masses of warm or cold air depending upon how far north or south the tropical or polar air may extend. If the warm air is cut off, the cyclone decreases in intensity and disappears; or, in the case of a new outbreak of polar air a new front is formed behind a too far advanced one; isolated masses of polar air are formed at lower latitudes. This is the formation of great anticyclones, which bring good weather.

In the case of the individual cyclone, the phenomena along this line of discontinuity are about as follows: That part of the line which lies in a general easterly direction from the center of the cyclone is known as the *steering-line.* South of it the air is moving from the south; north of it the air is from the east. Along the line the warm southerly air rises over the denser easterly air. Passing through the center of the cyclone the line extends off in a southwesterly direction and forms the western boundary of the warm tongue of southerly air, and the eastern front of an advancing wedge of cooler northwesterly air. This line is known as the *squall line,* and its passage is frequently accompanied by considerable violence, with thunderstorms and sometimes tornadoes, but usually with only a strong blow, a rise of pressure, a drop of temperature, and, of course, a change of wind direction.

It was on the basis of the advance of these lines of discontinuity that Mr. Andrus was able to predict the path and advise the balloonists to make as little westerly progress as possible during the first night, to stay as far east and north as possible, even if it were necessary to disregard the usual practise in ballooning of staying as low as possible to avoid expenditure of ballast early in the race. The winner followed this advice and had landed in Vermont many hours before the others who had reached no greater distance than Illinois and lower Michigan. This fact demonstrates very clearly that, as Mr. Upson frankly confesses and as Mr. Andrus emphatically states, it was meteorology that won the race.

C. LEROY MEISINGER

WASHINGTON, D. C.

[4] Bjerknes, J., "On the Structure of Moving Cyclones," *Monthly Weather Review,* February, 1919, pp. 95–99; "The Structure of the Atmosphere when Rain is Falling" (abstract), *ibid.,* July, 1920, p. 401; Bjerknes, V., "The Meteorology of the Temperate Zone and the General Atmospheric Circulation," *ibid.,* January, 1921, pp. 1–3; appeared also in *Nature* (London), June 24, 1920, pp. 522–524.

SPECIAL ARTICLES

THE CATALYTIC PROPERTIES OF THE RESPIRATORY METALS[1]

THE more important physical and chemical properties of the respiratory metals—iron, copper, manganese and vanadium—have long

[1] Contributions from the Bermuda Biological Station for Research, No. 123.

been known. Hitherto, however, the evident points of similarity which these metals possess have not been offered to explain their singular activity in respiration.

In the first place, as Griffiths[2] has pointed out, the atomic weights of these metals differ very slightly from one another: Mn = 55; Cu = 53; Fe = 55.9; V = 51.[3] Is such a condition purely accidental, or does it indicate something concerning the chemical affinities of the proteins with which these metals are associated? It should be noted also that the valences of the elements in question are variable to an unusual degree (Cu, 1–2; Mn, 2–7; Fe, 2–3; V, 3–5). So marked a degree of variation may be without theoretical significance, yet it is an interesting coincidence. These metals also closely approximate one another in specific gravity. In addition they all form oxides with great facility. But perhaps the most suggestive property which they have in common is that of catalysis.

It is a commonplace of inorganic chemistry that minute amounts of iron and of manganese hasten many reactions. This is likewise true of both copper and vanadium. But it is much more significant that these same elements also have a very profound catalytic effect upon many physiological processes. One part of manganese in one million greatly accelerates the growth rate of Aspergillus niger.[4] Moreover, the salts of copper, iron and manganese serve as powerful catalaysers for peroxides, and will in some cases replace the enzyme peroxidase. Bertrand[5] believed that his enzyme "laccase" owed its activity to manganese, but it was subsequently shown by Bach[6] that iron could take the place of manganese without altering the activity of "laccase."[7] This latter fact serves as a striking parallel to the replacement of iron by copper and manganese in certain of the respiratory pigments. But this parallel may be pushed still further. When acting upon peroxides, these metals are serving in the capacity of catalysts. Now, it is not wholly impossible that the respiratory metals serve in the same way.

Alsberg and Clark[8] believe that the copper of hæmocyanin acts as a catalyst for oxygen, and if this be the case, the oxygen would be more readily given off to such acceptors as are present in the tissues, thus making hæmocyanin in reality analogous to a peroxide-peroxidase system. As for vanadium, Hecht[9] holds (on the grounds of the relatively low binding power for oxygen which Winterstein[10] reports for ascidian blood) that vanadium, too, probably serves the *rôle* of catalyst in the blood of tunicates. Also, from the description which Griffiths[11] gives of his pinnaglobin,[12] it is not at all impossible that the manganese of this pigment serves in a similar capacity. The fact that the metals are always present in very small quantities further strengthens the catalyst hypothesis. Hæmocyanin, which has a molecular weight of 18.762 (Griffiths), has in its molecule only 63.6 gram molecules of copper. Furthermore, one should recall that in certain sluggish animals respiratory pigments are present which are not associated with any oxidizing metals. These have been investigated extensively by Griffiths,[13] and are called by him achroglobins. An α-achroglobin is found in a limpet, *Patella vulgata*, and a β-achroglobin in chitons. A γ-achroblobin was described for

[2] "Respiratory Proteids," London, 1877, p. 60.

[3] Since Griffith's work, vanadium has been described by Henze (1911–12, *Zeits. physiol. Chem.*, 72, 494; 79, 215) for the blood of ascidians. The writer includes it, therefore, with the list of Griffiths.

[4] Bertrand, C. R., Acad. Sci., Paris, 1912, 154, 381.

[5] C. R. Acad. Sci., Paris, 1897, 124, 1032.

[6] *Chem. Berichte*, 1910, 43, 364.

[7] Bayliss, "Principles of Gen. Physiol.," 1918, London, p. 585.

[8] *Jour. Biol. Chem.*, 1914, 19, 503.

[9] *Amer. Jour. Physiol.*, 1918, 40, 165.

[10] *Biochem. Zeits.*, 1909, 19, 384.

[11] "Respiratory Proteids," London, 1897.

[12] A respiratory protein containing manganese. It was first isolated from *Pinna squamosa*, from which it derives its name.

[13] "Respiratory Proteids," London, 1897.

ascidians, but the presence of vanadium in association with the proteid escaped Griffith's observation. Whether non-metallic respiratory pigments represent degeneration, or whether they are phylogenetic predecessors of metallic pigments, is difficult to decide; but their presence in the animal kingdom shows that the function of oxygenation is not dependent upon the presence of a metal in the pigment molecule—a fact which gives strong indication that the association with metals was occasioned by the need of a greater capacity for ready oxidation and reduction, the need, that is, of a catalyst.

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THE INFLUENCE OF HEAT AND OXIDATION UPON THE NUTRITIVE AND ANTISCORBUTIC PROPERTIES OF COW'S MILK[1]

In a recent paper[2] from the Minnesota Experiment Station we submitted data which indicated that the nutritive and antiscorbutic properties of cow's milk are dependent upon the nature of the feeding materials which constitute the dairy ration.

In April, 1920, a series of studies was initiated with the view of ascertaining the influence of heat upon the nutritive properties and the antiscorbutic potency of milk. The experimental milk used in these studies was obtained from an Ayershire cow fed upon a ration composed of the same types of feeding materials throughout the experimental period. By this method it was hoped that we might eliminate fluctuations in the vitamine content of the dairy ration and thereby reduce to a minimum any variations in the nutritive properties of the milk.

In these studies we have used a total of 163 guinea pigs, and control groups were included in each series. In the first series of experiments it was found that boiled milk was practically equal, in nutritive properties, to the unheated raw milk. The pasteurized milk, heated at 145° F. for 30 minutes, produced scurvy very quickly and all of the animals died in a very short time. Examination revealed the fact that the pasteurized milks had been stirred rather violently with motor-driven propellors, while the boiled milk had not been stirred mechanically. This led us to believe that oxidation had occurred in the pasteurized milks due to the intimate contact of air with the milk particles. Consequently, many new animals have been added with the result that we have been able to show that the nutritive and antiscorbutic properties of cow's milk are destroyed by oxidation. Some destruction occurs when air is bubbled through milk at 145° F. for 30 minutes, but the destruction is much more marked when oxygen or hydrogen peroxide is used. Oxygen and hydrogen peroxide will destroy the antiscorbutic accessory at room temperature although the destructive action is hastened as the temperature increases. Milk may be pasteurized in closed vessels or boiled in the open air without appearing to lose its nutritive and antiscorbutic properties when fed to guinea pigs. When carbon dioxide is bubbled through the milk, it compares very favorably in nutritive properties with the raw milk.

Our work, now in progress, on orange juice shows that the antiscorbutic properties are not destroyed by boiling for 30 minutes. At least, if destruction occurs it is not discernible with the methods employed. Hydrogen peroxide destroys the antiscorbutic factor in orange juice at room temperature, and the speed of the oxidation is hastened as the temperature increases. Oxidation would appear to be a more important factor than heating as far as the nutritive and antiscorbutic properties of milk are concerned.

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[1] Published with the approval of the director as Paper No. 247, of the Journal Series of the Minnesota Agricultural Experiment Station.

[2] Dutcher, R. A., Eckles, C. H., Dahle, C. D., Mead, S. W., and Schaefer, O. G., *J. Biol. Chem.*, XLV., 119–132, December, 1920.